

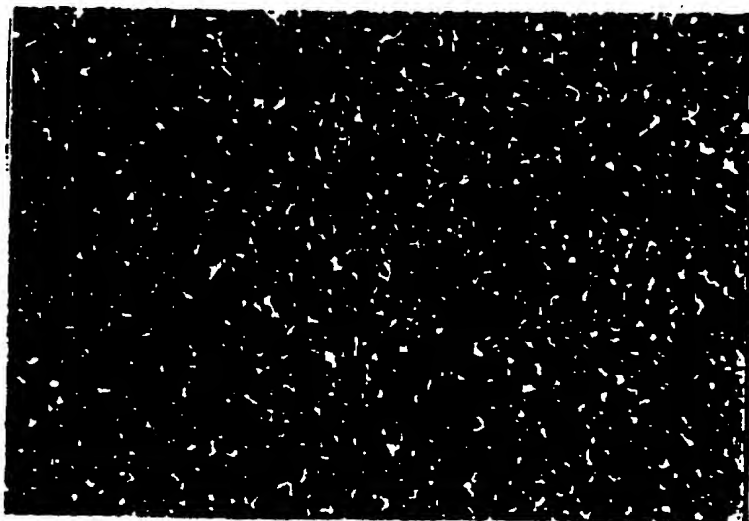


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<b>(21) International Application Number:</b> PCT/SE97/01243 <b>(22) International Filing Date:</b> 8 July 1997 (08.07.97)  <b>(30) Priority Data:</b> 9602811-3 19 July 1996 (19.07.96) SE  <b>(71) Applicant (for all designated States except US):</b> SANDVIK AB (publ) [SE/SE]; S-811 81 Sandviken (SE).  <b>(72) Inventors; and</b> <b>(75) Inventors/Applicants (for US only):</b> WALDENSTRÖM, Mats [SE/SE]; Thaliavägen 31, S-161 40 Bromma (SE). ÖSTLUND, Åke [SE/SE]; Sedelvägen 12, S-129 32 Hägersten (SE). ALM, Ove [SE/SE]; Storsvängen 136, S-129 44 Hägersten (SE).  <b>(74) Agents:</b> ÖSTLUND, Alf et al.; Sandvik AB, Patent Dept., S- 811 81 Sandviken (SE).		<b>(81) Designated States:</b> CN, JP, KR, RU, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).  <b>Published</b> <i>With international search report.</i>

**(54) Title:** CEMENTED CARBIDE INSERT FOR TURNING, MILLING AND DRILLING**(57) Abstract**

The present invention relates to a cemented carbide insert with excellent properties for machining of steels and stainless steels. The cemented carbide comprises WC and 4-25 wt.% Co. The WC-grains have an average grain size in the range 0.2-3.5  $\mu\text{m}$  and a narrow grain size distribution in the range 0-4.5  $\mu\text{m}$ . According to the method of the invention, a cemented carbide cutting tool insert is made by mixing powders of WC, TiC, TaC and/or NbC, binder metal and pressing agent, drying preferably by spray drying, pressing to inserts and sintering. The method is characterised in that a deagglomerated WC-powder with a narrow grain size distribution is used, that the powders of TiC, TaC and/or NbC are deagglomerated and that the mixing is wet mixing with no change in grain size or grain size distribution.



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Cemented carbide insert for turning, milling and  
drilling

5 The present invention relates to a cemented carbide cutting tool insert, particularly useful for turning, milling and drilling of steels and stainless steels.

Conventional cemented carbide inserts are produced by powder metallurgical methods including milling of a powder mixture forming the hard constituents and the binder phase, pressing and sintering. The milling operation is an intensive milling in mills of different sizes and with the aid of milling bodies. The milling time is of the order of several hours up to several days. Such processing is believed to be necessary in order to obtain a uniform distribution of the binder phase in the milled mixture. It is further believed that the intensive milling creates a reactivity of the mixture which further promotes the formation of a dense structure. However, milling has its disadvantages. During the long milling time the milling bodies are worn and contaminate the milled mixture. Furthermore even after an extended milling a random rather than an ideal homogeneous mixture may be obtained. Thus, the properties of the sintered cemented carbide containing two or more components depend on how the starting materials are mixed.

There exist alternative technologies to intensive milling for production of cemented carbide, for example, use of particles coated with binder phase metal. The coating methods include fluidized bed methods, solgel techniques, electrolytic coating, PVD coating or other methods such as disclosed in e. g. GB 346,473, US 5,529,804 or US 5,505,902. Coated carbide particles could be mixed with additional amounts of cobalt and other carbide powders to obtain the desired final

material composition, pressed and sintered to a dense structure.

During metal cutting operations like turning, milling and drilling the general properties such as hardness, resistance against plastic deformation, resistance against formation of thermal fatigue cracks are to a great extent related to the volume fraction of the hard phases and the binder phase in the sintered cemented carbide body. It is well known that increasing the amount of the binder phase reduces the resistance to plastic deformation. Different cutting conditions require different properties of the cutting insert. When cutting of steels with raw surface zones (e.g. rolled, forged or cast) a coated cemented carbide insert must consist of tough cemented carbide and have a very good coating adhesion as well. When turning, milling or drilling in low alloyed steels or stainless steels the adhesive wear is generally the dominating wear type.

Measures can be taken to improve the cutting performance with respect to a specific wear type. However, very often such action will have an negative effect on other wear properties.

The influence of some possible measures is given below:

1. Milling, turning or drilling at high cutting speeds and high cutting edge temperature require a cemented carbide with a rather large amount of cubic carbides (a solid solution of WC-TiC-TaC-NbC). Thermal fatigue cracks will often more easily develop in such carbides.

2. The formation of thermal fatigue cracks can be reduced by lowering the binder phase content. However, such action will lower the toughness properties of the cutting insert which is not desirable.

3. Improved abrasive wear can be obtained by increasing the coating thickness. However, thick coatings increase the risk for flaking and will lower the resistance to adhesive wear.

5 It has now surprisingly been found that cemented carbide inserts made from powder mixtures with hard constituents with narrow grain size distributions and without conventional milling have excellent cutting performance in steels and stainless steels with or  
10 without raw surfaces in turning, milling and drilling under both dry and wet conditions.

Fig. 1 shows in 1200X the microstructure of a cemented carbide insert according to the invention.

15 Fig. 2 shows in 1200X the microstructure of a corresponding insert made according to prior art.

According to the invention there is now provided cemented carbide inserts with excellent properties for machining of steels and stainless steels comprising WC and 4 - 20 wt-% Co, preferably 5 - 12.5 wt-% Co and 0 -  
20 30 wt-% cubic carbide, preferably 0 - 15 wt-% cubic carbide, most preferably 0 - 10 wt-% cubic carbide such as TiC, TaC, NbC or mixtures thereof. The WC-grains have an average grain size in the range 0.8 - 3.5  $\mu\text{m}$ , preferably 1.0 - 3.0  $\mu\text{m}$ . The microstructure of the cemented  
25 carbide according to the invention is further characterized by a narrow grain size distribution of WC in the range 0.5 - 4.5  $\mu\text{m}$ , and a lower tendency for the cubic carbide particles, when present, to form long range skeleton, compared to conventional cemented carbide.

30 In another alternative embodiment there is provided cemented carbide inserts comprising WC and 10 - 25 wt-% Co, preferably 15 - 20 wt-% Co, and <2 wt-%, preferably <1 wt-% cubic carbides such as  $\text{Cr}_3\text{C}_2$  and/or VC added as grain growth inhibitors. The WC-grains have an average  
35 grain size 0.2 - 1.0  $\mu\text{m}$ . The microstructure of cemented

carbide according to the invention is further characterized by a narrow grain size distribution of WC in the range 0 - 1.5  $\mu\text{m}$ .

5 The amount of W dissolved in binder phase is controlled by adjustment of the carbon content by small additions of carbon black or pure tungsten powder. The W-content in the binder phase can be expressed as the "CW-ratio" defined as

$$\text{CW-ratio} = M_s / (\text{wt\%Co} * 0.0161)$$

10 where  $M_s$  is the measured saturation magnetization of the sintered cemented carbide body in kA/m and wt% Co is the weight percentage of Co in the cemented carbide. The CW-ratio in inserts according to the invention shall be 0.82 - 1.0, preferably 0.86 - 0.96.

15 The sintered inserts according to the invention are used coated or uncoated, preferably coated with MTCVD, conventional CVD or PVD with or without  $\text{Al}_2\text{O}_3$ . In particular, multilayer coatings comprising  $\text{TiC}_x\text{N}_y\text{O}_z$  with columnar grains followed by a layer of  $\alpha\text{-Al}_2\text{O}_3$ ,  $\kappa\text{-Al}_2\text{O}_3$  or a mixture of  $\alpha$ - and  $\kappa\text{-Al}_2\text{O}_3$ , have shown good results. 20 In another preferred embodiment the coating described above is completed with a TiN-layer which could be brushed or used without brushing.

According to the method of the present invention WC- 25 powder with a narrow grain size distribution is wet mixed without milling with deagglomerated powder of other carbides generally TiC, TaC and/or NbC, binder metal and pressing agent, dried preferably by spray drying, pressed to inserts and sintered.

30 WC-powder with a narrow grain size distributions according to the invention with eliminated coarse grain tails  $>4.5 \mu\text{m}$  and with eliminated fine grain tails,  $<0.5 \mu\text{m}$ , are prepared by sieving such as in a jetmill-classifier. It is essential according to the invention 35 that the mixing takes place without milling i.e. there

should be no change in grain size or grain size distribution as a result of the mixing.

Hard constituents with narrow grain size distributions according to the alternative embodiment with  
5 eliminated coarse grain tails  $>1.5 \mu\text{m}$  are prepared by sieving such as in a jetmill classifier. It is essential according to the invention that the mixing takes place without milling i.e. there should be no change in grain size or grain size distribution as a result of the  
10 mixing.

In a preferred embodiment the hard constituents, at least those with narrow grain size distribution, are after careful deagglomeration coated with binder metal using methods disclosed in US 5,505,902 or US 5,529,804.  
15 In such case the cemented carbide powder according to the invention consists preferably of Co-coated WC + Co-binder, with or without additions of the cubic carbides, TiC, TaC, NbC, (Ti,W)C, (Ta,Nb)C, (Ti,Ta,Nb)C, (W,Ta,Nb)C, (W,Ti,Ta,Nb)C or  $\text{Cr}_3\text{C}_2$  and/or VC coated or  
20 uncoated, preferably uncoated, possibly with further additions of Co-powder in order to obtain the desired final composition.

#### Example 1

25 A. Cemented carbide tool inserts of the type SEMN 1204 AZ, an insert for milling, with the composition 9.1 wt% Co, 1.23 wt% TaC and 0.30 wt% NbC and rest WC with a grain size of  $1.6 \mu\text{m}$  were produced according to the invention. Cobalt coated WC, WC-2 wt% Co, prepared  
30 according to US 5,505,902 was carefully deagglomerated in a laboratory jetmill equipment, mixed with additional amounts of Co and deagglomerated uncoated (Ta,Nb)C and TaC powders to obtain the desired material composition. The mixing was carried out in an ethanol and water  
35 solution (0.25 l fluid per kg cemented carbide powder)

for 2 hours in a laboratory mixer and the batch size was 10 kg. Furthermore, 2 wt% lubricant, was added to the slurry. The carbon content was adjusted with carbon black to a binder phase highly alloyed with W corresponding to a CW-ratio of 0.89. After spray drying, the inserts were pressed and sintered according to standard practise and dense structures with no porosity were obtained, Fig. 1.

Before coating a negative chamfer with an angle of 20° was ground around the whole insert.

The inserts were coated with a 0.5 µm equiaxed TiCN-layer (with a high nitrogen content corresponding to an estimated C/N-ratio of 0.05) followed by a 4 µm thick TiCN-layer with columnar grains by using MTCVD-technique (temperature 885-850 °C and CH<sub>3</sub>CN as the carbon and nitrogen source). In subsequent steps during the same coating cycle, a 1.0 µm thick layer of Al<sub>2</sub>O<sub>3</sub> was deposited using a temperature 970 °C and a concentration of H<sub>2</sub>S dopant of 0.4 % as disclosed in EP-A-523 021. A thin (0.3 µm) layer of TiN was deposited on top according to known CVD-technique. XRD-measurement showed that the Al<sub>2</sub>O<sub>3</sub>-layer consisted of 100 % κ-phase.

The coated inserts were brushed by a nylon straw brush containing SiC grains. Examination of the brushed inserts in a light microscope showed that the thin TiN-layer had been brushed away only along the cutting edge leaving there a smooth Al<sub>2</sub>O<sub>3</sub>-layer surface.

Coating thickness measurements on cross sectioned brushed samples showed no reduction of the coating along the edge line except for the outer TiN-layer that was removed.

B. Cemented carbide tool inserts of the type SEMN 1204 AZ with the same chemical composition, average grain size of WC, CW-ratio, chamfering and CVD-coating respectively but produced from powder manufactured with



conventional ball milling techniques, Fig. 2, were used as reference.

Inserts from A were compared to inserts from B in a wet milling test in a medium alloyed steel (HB=210) with hot rolled and rusty surfaces. Two parallel bars each of a thickness of 33 mm were centrally positioned relative to the cutter body (diameter 100 mm) and with an air gap of 10 mm between them.

The cutting data were:

Speed= 160 m/min

Feed= 0.20 mm/rev

Cutting depth= 2 mm, single tooth milling with coolant.

Evaluated life length of variant A according to the invention was 3600 mm and for the standard variant B only 2400 mm. Since the CW-ratio, the negative chamfer and the coatings were equal for variants A and B, the differences in cutting performance depend on the improved properties obtained by the invention.

#### Example 2

A. Cemented carbide tool inserts of the type SEMN 1204 AZ according to the invention identical to the test specimen (A) in Example 1.

B. Cemented carbide tool inserts of the type SEMN 1204 AZ identical to the reference specimen (B) in Example 1.

C. A strongly competitive cemented carbide grade of the type SEKN 1204 from an external leading carbide producer with the composition 7.5 wt-% Co, 0.4 wt-% TaC, 0.1 wt-% NbC, 0.3 wt-% TiC rest WC and a CW-ratio of 0.95. The insert was provided with a coating consisting of a 0.5  $\mu\text{m}$  equiaxed TiCN-layer, 2.1  $\mu\text{m}$  columnar TiCN-layer, 2.2  $\mu\text{m}$   $\kappa$ -Al<sub>2</sub>O<sub>3</sub>-layer and a 0.3  $\mu\text{m}$  TiN-layer.

Inserts from A were compared against inserts from B and C in a dry milling test in a low alloyed steel (HB=300) with premachined surfaces. A bar with a thickness of 180 mm was centrally positioned relative to the  
5 cutter body (diameter 250 mm)

The cutting data were:

Speed= 150 m/min,

Feed= 0.23 mm/rev

10 Cutting depth= 2 mm, single tooth milling dry conditions.

Insert B broke after 6000 mm after comb crack formation and chipping and insert C broke after 4800 mm by a similar wear pattern. Finally, insert A according to the invention, broke after 8000 mm.

15

### Example 3

A. Cemented carbide tool inserts of the type CNMG 120408-QM, an insert for turning, with the composition 8.0 wt% Co, and rest WC with a grain size of 3.0  $\mu\text{m}$  were  
20 produced according to the invention. Cobalt coated WC, WC-8 wt% Co, prepared according to US 5,505,902 was carefully deagglomerated in a laboratory jetmill equipment. The mixing was carried out in an ethanol and water solution (0.25 l fluid per kg cemented carbide  
25 powder) for 2 hours in a laboratory mixer and the batch size was 10 kg. Furthermore, 2 wt% lubricant, was added to the slurry. The carbon content was adjusted with carbon black to a binder phase alloyed with W corresponding to a CW-ratio of 0.93. After spray drying, the  
30 inserts were pressed and sintered according to standard practise and dense structures with no porosity were obtained.

The inserts were coated with conventional CVD TiN+TiCN, 1+1  $\mu\text{m}$ .

5 B. Cemented carbide tool inserts of the type CNMG 120408-QM with the same chemical composition, average grain size of WC, CW-ratio and the same CVD-coating respectively but produced from powder manufactured with conventional ball milling techniques were used as reference.

10 Inserts from A and B were compared in a face turning test where the resistance against plastic deformation was measured as the flank wear. The work piece material was a rather highly alloyed steel, a bar with diameter 180 mm (HB=310). The cutting data were:

Speed= 290 m/min

Feed= 0.30 mm/rev

Depth of cut= 2 mm

15 The flank wear after two passages (average for three edges per variant) was found to be 0.27 mm for variant A according to the invention and 0.30 for variant B.

#### Example 4

20 A. Cemented carbide inserts of the type CNMG120408-MM, an insert for turning, with the composition 10.5 wt-% Co, 1.16 wt-% Ta, 0.28 wt-% Nb and rest WC with a grain size of 1.6  $\mu$ m were produced according to the invention. Cobalt coated WC, WC-6 wt% Co, prepared  
25 according to US 5,505,902 was carefully deagglomerated in a laboratory jetmill equipment, mixed with additional amounts of Co and deagglomerated uncoated (Ta,Nb)C and TaC powders to obtain desired material composition. The mixing was carried out in an ethanol and water solution.  
30 (0.25 l fluid per kg cemented carbide powder) for 2 hours in a laboratory mixer and the batch size was 10 kg. Furthermore, 2 wt% lubricant, was added to the slurry. The carbon content was adjusted with carbon black to a binder phase highly alloyed with W corresponding to a CW-ratio of 0.87. After spray drying, the  
35

inserts were pressed and sintered according to standard practise and dense structures with no porosity were obtained.

5 The inserts were coated with an innermost 0.5  $\mu\text{m}$  equiaxed TiCN-layer with a high nitrogen content, corresponding to an estimated C/N ratio of 0.05, followed by a 4.2  $\mu\text{m}$  thick layer of columnar TiCN deposited using MT-CVD technique. In subsequent steps during the same coating process a 1.0  $\mu\text{m}$  layer of  $\text{Al}_2\text{O}_3$  10 consisting of pure  $\kappa$ -phase according to procedure disclosed in EP-A-523 021. A thin, 0.5  $\mu\text{m}$ , TiN layer was deposited, during the same cycle, on top of the  $\text{Al}_2\text{O}_3$ -layer.

15 The coated insert was brushed by a SiC containing nylon straw brush after coating, removing the outer TiN layer on the edge.

B. Cemented carbide tool inserts of the type CNMG120408-MM with the same chemical composition, average grain size of WC, CW-ratio and the same CVD-coating respectively but produced from powder manufactured with conventional ball milling techniques were 20 used as reference.

Inserts from A and B were compared in facing of a bar, diameter 180, with two opposite flat sides 25 (thickness 120 mm) in 4LR60 material (a stainless steel).

The cutting data were:

Feed= 0.25 mm/rev,

Speed= 180 m/min and

30 Depth of cut= 2.0 mm.

The wear mechanism in this test was chipping of the edge.

## Result

Insert	Number of cuts
A, according to the invention	19
B	15

Example 5

5 A. Cemented carbide turning tool inserts of the type  
CNMG120408-PM with the composition 5.48 wt-% Co, 3.30  
wt-% Ta, 2.06 wt-% Nb, 2.04 wt% Ti and rest WC with a  
grain size of 1.6  $\mu\text{m}$  were produced according to the  
invention. Cobalt coated WC, WC-5 wt% Co, prepared  
10 according to US 5,505,902 was carefully deagglomerated  
in a laboratory jetmill equipment, mixed with additional  
amounts of Co and deagglomerated uncoated (Ta,Nb)C, TaC  
and (Ti,W)C powders to obtain desired material compo-  
sition. The mixing was carried out in an ethanol and  
water solution (0.25 l fluid per kg cemented carbide  
15 powder) for 2 hours in a laboratory mixer and the batch  
size was 10 kg. Furthermore, 2 wt% lubricant, was added  
to the slurry. The carbon content was adjusted with  
tungsten powder to a binder phase alloyed with W  
corresponding to a CW-ratio of 0.95. After spray drying,  
20 the inserts were pressed and sintered according to  
standard practise and dense structures with no porosity  
were obtained.

The inserts were coated with an innermost 5  $\mu\text{m}$  layer  
of TiCN, followed by in subsequent steps during the same  
25 coating process a 6  $\mu\text{m}$  layer of  $\text{Al}_2\text{O}_3$ .

B. Cemented carbide turning tool inserts of the type  
CNMG120408-PM with the composition 5.48 wt-% Co, 3.30  
wt-% Ta, 2.06 wt-% Nb, 2.04 wt% Ti and rest WC with a  
grain size of 1.6  $\mu\text{m}$  were produced according to the  
30 invention. Uncoated deagglomerated WC was mixed with  
additional amounts of Co and deagglomerated uncoated  
(Ta,Nb)C, TaC and (Ti,W)C powders to obtain a desired

material composition. The mixing was carried out in an ethanol and water solution (0.25 l fluid per kg cemented carbide powder) for 2 hours in a laboratory mixer and the batch size was 10 kg. Furthermore, 2 wt% lubricant, 5 was added to the slurry. The carbon content was adjusted with tungsten powder to a binder phase alloyed with W corresponding to a CW-ratio of 0.95. After spray drying, the inserts were pressed and sintered according to standard practise and dense structures with no porosity 10 were obtained.

The inserts were coated with an innermost 5  $\mu\text{m}$  layer of TiCN, followed by in subsequent steps during the same coating process a 6  $\mu\text{m}$  layer of  $\text{Al}_2\text{O}_3$ .

C. Cemented carbide turning tool inserts of the type 15 CNMG120408-PM with the composition 5.48 wt-% Co, 3.30 wt-% Ta, 2.06 wt-% Nb, 2.04 wt% Ti and rest WC produced from powder manufactured with conventional ball milling techniques with the same CW-ratio and almost the same average WC-grain size as insert A and B were coated with 20 the same coating as insert A and B.

Inserts from A, B and C were compared in an external longitudinal turning test with cutting speed 220 m/min and 190 m/min resp., a depth of cut of 2 mm, and a feed per tooth equal to 0.7 mm/revolution. The work piece 25 material was SS 2541 with a hardness of 300 HB and a diameter of 160 mm. The wear criteria in this test was the measure of the edge depression in  $\mu\text{m}$ , which reflects the inverse resistance against plastic deformation. A lower value of the edge depression indicates higher re- 30 sistance against plastic deformation.

The following results were obtained:

	v= 190 m/min	v= 220 m/min
	edge depression, $\mu\text{m}$	edge depression, $\mu\text{m}$
5	A 59	85
	B 56	93
	C 89	116

Since the general toughness behaviour was similar it is clear that both insert A produced from Co-coated WC and insert B produced from uncoated WC both according to the invention, performed better than insert C produced with conventional techniques.

#### Example 6

A. Cemented carbide turning tool inserts of the type CNMG120408-PM with the composition 5.48 wt-% Co, 3.30 wt-% Ta, 2.06 wt-% Nb, 2.04 wt-% Ti and rest WC with a grain size of 1.6  $\mu\text{m}$  were produced according to the invention. Cobalt coated WC, WC-5 wt% Co, prepared according to US 5,505,902 was carefully deagglomerated in a laboratory jetmill equipment, mixed with additional amounts of Co and deagglomerated uncoated (Ta,Nb)C, TaC and (Ti,W)C powders to obtain desired material composition. The mixing was carried out in an ethanol and water solution (0.25 l fluid per kg cemented carbide powder) for 2 hours in a laboratory mixer and the batch size was 10 kg. Furthermore, 2 wt% lubricant, was added to the slurry. The carbon content was adjusted with tungsten powder to a binder phase alloyed with W corresponding to a CW-ratio of 0.95. After spray drying, the inserts were pressed and sintered according to standard practise and dense structures with no porosity were obtained.

The inserts were coated with an innermost 5  $\mu\text{m}$  layer of TiCN, followed by in subsequent steps during the same coating process a 6  $\mu\text{m}$  layer of  $\text{Al}_2\text{O}_3$ .

B. Cemented carbide turning tool inserts of the type CNMG120408-PM with the composition 5.48 wt-% Co, 3.30 wt-% Ta, 2.06 wt-% Nb, 2.04 wt% Ti and rest WC with a grain size of 1.6  $\mu\text{m}$  were produced according to the invention. Uncoated deagglomerated WC was mixed with additional amounts of Co and deagglomerated uncoated (Ta,Nb)C, TaC and (Ti,W)C powders to obtain desired material composition. The mixing was carried out in an ethanol and water solution (0.25 l fluid per kg cemented carbide powder) for 2 hours in a laboratory mixer and the batch size was 10 kg. Furthermore, 2 wt% lubricant, was added to the slurry. The carbon content was adjusted with tungsten powder to a binder phase alloyed with W corresponding to a CW-ratio of 0.95. After spray drying, the inserts were pressed and sintered according to standard practise and dense structures with no porosity were obtained.

The inserts were coated with an innermost 5  $\mu\text{m}$  layer of TiCN, followed by in subsequent steps during the same coating process a 6  $\mu\text{m}$  layer of  $\text{Al}_2\text{O}_3$ .

C. Cemented carbide turning tool inserts of the type CNMG120408-PM with the composition 5.48 wt-% Co, 3.30 wt-% Ta, 2.06 wt-% Nb, 2.04 wt% Ti and rest WC produced from powder manufactured with conventional ball milling techniques with the same CW-ratio and almost the same average WC-grain size as insert A and B were coated with the same coating as insert A and B.

Inserts from A, B and C were compared in a external longitudinal turning test with cutting data 240 m/min, a dept of cut of 2 mm, and a feed per tooth equal to 0.7 mm/revolution. The work piece material was SS 2541 with an hardness of 300 HB and a diameter of 160 mm. The wear criteria in this test was the measure of the maximum flank wear after 5 min in cutting time, which reflects the resistance against plastic deformation.



The following results were obtained  
max. flank wear,  $\mu\text{m}$

	A	28
	B	35
5	C	38

Since the general toughness behaviour was similar it is clear that both insert A produced from Co-coated WC, and insert B produced from uncoated WC both according to the invention, performed better than insert C produced with conventional techniques.

Claims

1. A cemented carbide insert with excellent properties for machining of steels and stainless steels comprising WC and 4 - 25 wt-% Co in which the WC-grains have an average grain size in the range 0.2 - 3.5  $\mu\text{m}$  characterised in that the WC grains have a narrow grain size distribution in the range 0 - 4.5  $\mu\text{m}$ .

2. A cemented carbide insert according to the preceding claim comprising WC, 5 - 20 wt-% Co and 0 - 30 wt-% cubic carbide, preferably 0 - 15 wt-% cubic carbide, most preferably 0 - 10 wt-% cubic carbide such as TiC, TaC, NbC or mixtures thereof in which the WC-grains have an average grain size in the range 0.8 - 3.5  $\mu\text{m}$  preferably 1.0 - 3.0  $\mu\text{m}$  characterised in that the WC grains have a narrow grain size distribution in the range 0.5 - 4.5  $\mu\text{m}$ .

3. A cemented carbide insert according to claim 1 comprising WC and 10 - 25 wt-% Co, preferably 15 - 20 wt-% Co in which the WC grains have an average grain size 0.2 - 1.0  $\mu\text{m}$  characterised in a narrow grain size distribution of WC in the range 0 - 1.5  $\mu\text{m}$ .

4. A cemented carbide insert according to any of the preceding claim characterised in that the W-content in the binder phase expressed as the "CW-ratio" defined as

$$\text{CW-ratio} = M_s / \text{wt\%Co} * 0.0161$$

where  $M_s$  is the measured saturation magnetization of the sintered cemented carbide insert in kA/m and wt% Co is the weight percentage of Co in the cemented carbide shall be 0.82 - 1.0, preferably 0.86 - 0.96.

5. A cemented carbide insert according to any of the preceding claims characterised in that said insert is provided with a thin wear resistant coating.

6. A cemented carbide insert according to claim 5 characterised in that said coating comprises

TiC<sub>x</sub>N<sub>y</sub>O<sub>z</sub> with columnar grains followed by a layer of  $\alpha$ -Al<sub>2</sub>O<sub>3</sub>,  $\kappa$ -Al<sub>2</sub>O<sub>3</sub> or a mixture of  $\alpha$ - and  $\kappa$ -Al<sub>2</sub>O<sub>3</sub>.

7. Method of making a cemented carbide cutting tool insert by mixing powders of WC, TiC, TaC and/or NbC, binder metal and pressing agent, drying preferably by spray drying, pressing to inserts and sintering  
5 c h a r a c t e r i s e d i n

- that a deagglomerated WC-powder with a narrow grain size distribution is used,

10 - that the powders of TiC, TaC and/or NbC are deagglomerated and

- that the mixing is wet mixing with no change in grain size or grain size distribution

8. Method according to claim 7

15 c h a r a c t e r i s e d i n that in the WC-powder with a narrow grain size distribution the coarse grain tails >4.5  $\mu$ m and fine grain tails, <0.5  $\mu$ m, are eliminated by sieving such as in a jetmill-classifier.

9. Method according to claim 7

20 c h a r a c t e r i s e d i n that in the WC-powder with a narrow grain size distribution the coarse grain tails >1.5  $\mu$ m is eliminated by sieving such as in a jetmill-classifier.

10. Method according to any of the claims 7-9

25 c h a r a c t e r i s e d i n that the WC grains are coated with binder metal and deagglomerated prior to the mixing.

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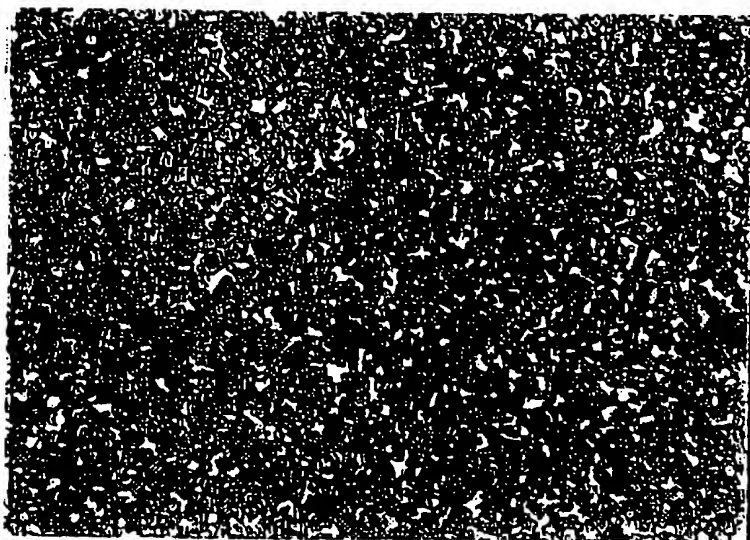


Fig. 1

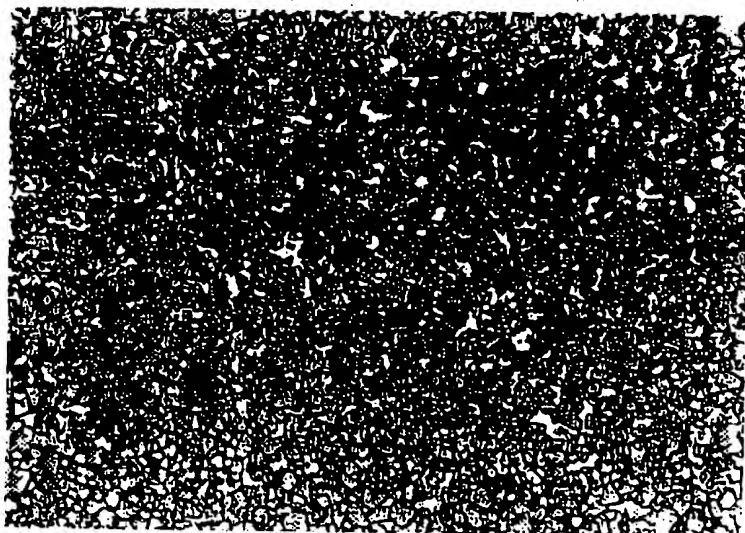


Fig. 2

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 97/01243

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: C22C 29/08

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: C22C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4923512 A (ED E. TIMM ET AL), 8 May 1990 (08.05.90), column 3, line 19 - line 40; column 9, line 31 - line 68	1,2,4
A	--	3,5,6,7-10
X	US 3660050 A (RALPH K. ILER ET AL), 2 May 1972 (02.05.72), column 1, line 1 - column 3, line 9; column 6, line 11 - line 32; column 9, line 13 - line 55, column 31, line 45 - column 32, line 17	1,3,4
A	--	2,5-6,7-10



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

5 November 1997

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Name and mailing address of the ISA/  
Swedish Patent Office  
Box 5055, S-102 42 STOCKHOLM  
Facsimile No. +46 8 666 02 86

Authorized officer

Nils Engnell  
Telephone No. +46 8 782 25 00

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 97/01243

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0240879 A2 (MITSUBISHI KINZOKU KABUSHIKI KAISHA), 14 October 1987 (14.10.87), column 2, line 1 - line 42	1,2
A	--	3-6,7-10
X	Dialog Information Services, File 351, DERWENT WPI, Dialog accession no. 010155859, WPI accession no. 95-057111/199508, (NGK SPARK PLUG CO LTD), "Tungstencarbide-base cemented carbide used for cutting tool - comprises hard phase having specified particle size distribution, and contg tungsten carbide and ferrous metal bonding phase", & JP,A,6335808, 19941206, 199508 B	1,2,3
A	--	4-6,7-10
P,X	Dialog Information Services, File 351, DERWENT WPI, Dialog accession no. 011397725, WPI accession no. 97-375632/199735, (KOBE STEEL LTD), "Hard tough cemented carbide - comprises mainly tungsten carbide, cobalt and nickel", & JP,A,9125185, 19970513, 199735 B	1
A	--	2-6,7-10
A	Dialog Information Services, File 351, DERWENT WPI, Dialog accession no. 011172064, WPI accession no. 97-149989/199714, (DIJET IND CO LTD), "Sintered hard material for water jet or wire drawing die nozzles - comprises iron, cobalt, and/or nickel, carbide and/or carbonitride of Gp-IVA transition metal, and tungsten carbide", & JP,A,9025535, 19970128, 199714 B	1-6,7,10
	--	

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 97/01243

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Dialog Information Services, File 351, DERWENT WPI, Dialog accession no. 008723156, WPI accession no. 91-227173/199131, (TOSHIBA TUNGALLOY KK), "Coated sintered hard alloy for intermittent cutting - has single or multilayers of ceramics on matrix of tungsten carbide or gp-IVA, pg-VA or gp-VIA carbide(s) or carbonitride(s)", JP,A, 3146677, 19910621, 199131 B  --	1-6,7-10
A	Dialog Information Services, File 351, DERWENT WPI, Dialog accession no. 008551086, WPI accession no. 91-055137/199108, (HITACHI TOOL KK), "Super-hard alloy prodn. - comprises hard phase of titanium- carbide, titanium-nitride and tungsten carbide and binder phase of iron-Gp. metal", JP,A, 3006349, 19910111, 199108 B  --	1-6,7-10
A	Dialog Information Services, File 351, DERWENT WPI, Dialog accession no. 004689404, WPI accession no. 86-192746/198630, (HITACHI CHOKO KK), "Ultrafine particles sintered hard alloy - comprises tungsten carbide hard phase bonded with iron and chromium gp elements contg. carbid(s)", JP,A, 61124548, 19860612, 198630 B  --	1-6,7-10
A	Dialog Information Services, File 351, DERWENT WPI, Dialog accession no. 004675229, WPI accession no. 86-178571/198628, (HITACHI CHOKO KK et al), "Hard alloy useful for cutting tools etc. comprises hard phase contg. tungsten carbide, and binder metal phase contg. iron-gp. and chromium-gp. elements", JP,A,61110745, 19860529, 198628 B  --	1-6,7-10
A	EP 0476632 A2 (KAWASAKI JUKOGYO KABUSHIKI KAISHA), 25 March 1992 (25.03.92), page 4, line 36 - page 5, line 19  -----	1-6,7-10

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

International application No.

PCT/SE 97/01243

Patent document cited in search report			Publication date	Patent family member(s)		Publication date
US	4923512	A	08/05/90	NONE		
US	3660050	A	02/05/72	AT	299562 A	15/05/72
				BE	751884 A	14/12/70
				CA	924738 A	17/04/73
				CH	545347 A	31/01/74
				DE	2030666 A	07/01/71
				FR	2047071 A	12/03/71
				GB	1315368 A	02/05/73
				LU	61174 A	24/08/70
				NL	7009125 A	28/12/70
				SE	7411630 A	16/09/74
				SE	7411631 A	16/09/74
				ZA	7004219 A	31/03/71
EP	0240879	A2	14/10/87	SE	0240879 T3	
				DE	3784754 A	22/04/93
				JP	1947234 C	10/07/95
				JP	6076639 B	28/09/94
				JP	62227059 A	06/10/87
				US	5068149 A	26/11/91
				US	5288676 A	22/02/94
				JP	62227060 A	06/10/87
EP	0476632	A2	25/03/92	CA	2051765 A,C	21/03/92
				JP	2599044 B	09/04/97
				JP	4365558 A	17/12/92
				KR	9406286 B	14/07/94
				US	5334561 A	02/08/94
				US	5434112 A	18/07/95
				JP	2540672 B	09/10/96
				JP	4348873 A	03/12/92